Integrated Planning Support System for Low-Income Housing

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Einleitung

Mit den steigenden Anforderungen an Bauwerke ist auch für Planungsaufgaben im Baubereich eine zunehmende Komplexität zu verzeichnen. Dies gilt sowohl für den Neubau, als auch besonders für den Altbau, der durch unsichere Kenngrößen besondere Schwierigkeiten an die Planung stellt. Zur Bewältigung dieser Planungsaufgaben gebietet sich die fachliche Unterstützung durch digitale Systeme und Werkzeuge. Entsprechende Systeme, die den Planer unterstützen existieren nicht oder nur unzureichend.

Die digitale Unterstützung der Planung ist Forschungs- und Arbeitsschwerpunkt der Professur Informatik in der Architektur (InfAR) der Bauhaus-Universität Weimar. Seit 1998 ist diese Forschungsarbeit in den Sonderforschungsbereich 524 Werkzeuge und Konstruktionen für die Revitalisierung von Bauwerken' durch ein eigenes Teilprojekt (D2) integriert. Die Installation einer Juniorprofessur 'Architekturinformatik' 2002 verstärkt die Bearbeitung in Forschung und Praxis.

Die in dem Tagungsband vorgestellten Arbeiten 'Architekturplanung im Bestand', 'Neue Techniken in der Bestandserfassung' , 'Das Bauwerk als Informationscontainer in den frühen Phasen der Bauaufnahme', 'Plausibilität im Planungsprozess - Digitale Planungshilfen für die Revitalisierung von Gebäuden', 'Computernetzwerke als Integrations- und Planungswerkzeuge', 'Vision eines mitwachsenden Geometriemodells für die computergestützte Bauaufnahme' und 'Integrated Planning Support System for Low-Income Housing' sind weitere Bausteine des Forschungsgebietes und stehen in unmittelbarem Zusammenhang zum hier präsentierten Thema.

In dem nachfolgenden Beitrag wird EIN Schwerpunkt aus diesem Forschungskomplex „Planen und Bauen im Bestand“ näher diskutiert.

…Creating rules for a game designed to make creativity possible. [1]

The research project called *‘Integrated Planning Support System for Low-Income Housing’* (IPSS) is focused on the development of a set of computer-based tools to support user-

[1] Habraken N. John: *Supports: an alternative to mass housing*, (translated by B. Valkenburg), Architectural Press, ISBN 0-85139-225-3, London, 1972.

designed housing strategies, by means of the integrative combination of Information Systems facilities, Computer Assisted Design tools and online communication techniques.

User-designed and self-built housing strategies correspond to non-paternalistic support methods that are not only capable to provide more diversity of dwellings than conventional mass housing programs, but also a bigger sense of appropriation and identification of the dweller with her habitat. Nevertheless, the user-dweller generally lacks of the appropriate technical and legal knowledge as well as the required basic techniques of housing design.[2] With this set of integrated computer-based planning tools, we expect to enable dwellers of scarce resources communities to efficiently plan their dwellings expansion, supported by a user-friendly tool that can gather this planning-relevant knowledge and apply it in response to their specific needs and preferences.

The aforementioned knowledge not only refers to urban development regulations, security norms or structural design, but it also refers to basic design standards that guarantee the quality and comfort of habitability minima. In this sense, it is also our goal to improve the spatial, functional and perhaps the constructive quality of user-designed dwellings.

In fact, we think that if we liberate the user-dweller of having to deal directly with this very specific collection of rules and housing design techniques, by delegating their processing and application to the intern calculation of the computer, we will achieve both, to increase creativity of user-dwellers and houses in conformity with the law, easy to incorporate into the official cadasters and studies.

Based on the basic principles of computer programming, we can induce that having a set of variables (spatial configurations) and a set of rules to combine them (spatial relationships) and to organize them (architectural layout) within a determined boundary (plot and urban development ordinance), a computer-based system is able to scan the more appropriate design solution with very few input data coming from the user-dweller.

The process of dwelling and the progressive planning

Already in 1962 N. John Habraken understands the act of dwelling as a process instead of as a static endproduct, and the housing as an open system that should consist of upgradeable, replaceable and interchangeable components. A system that merges various logical and physical components.

"On the other hand, if we understand housing not as a *closed good*, but as a *set of goods*, *services and conditions* that address differentiated needs, it is possible to conceive it according to diverse components that can be at different levels of lacks and that are also possible to correct independently". [3]

We are using as application case the Progressive Housing (PH) system, which belongs to user-designed and self-built housing strategies, and is one of the Chilean state housing

[2] vid. González, L.F.; *IPSS for low-income housing*, tech. report August 2001, http://infar.architektur.uni-weimar.de/infar/deu/forschung/tech_report/index.html
[3] Mac Donald, Joan; *Vivienda progresiva (Progressive Housing)*, ed. Corporación de Promoción Universitaria, Santiago de Chile, 1987.

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programs that has shown the best results in the last decade, in terms of the morphological diversity obtained among the design solutions of low-income housing.
A progressive dwelling is, basically, an incomplete house that requires to be consolidated over time, by its own inhabitants, depending on their needs and resources. It is aimed at the poorer low-income families.

From the social and the economic point of view, it assures shelter and property ownership, in a relatively quick manner, causing a decrease in the housing deficit within the population's poorer sectors, due to the very low cost of each dwelling. From the sociological point of view, it supports the processes of dweller's identification with her environment, not simply as a habitat, but, instead, individualizing the dwelling to the point that it is understood as *home*, unlike the sense of homogeneity felt toward most ready-to-use low-income housing. From the architectural point of view, it generates bigger diversity among the dwelling solutions, responding with more flexibility to the family dynamics, and generating new and interesting design alternatives that result from the creativity of their inhabitants.

The production of PH works – almost the same as the rest of the housing programs in Chile since 1978 - by means of a combination of public and private sector resources. Dwellers purchase a *dwelling basic unit* that consists of a serviced plot and a so called *sanitary unit*, which essentially means a bathroom and an adjacent space for laundry. Eventually, a room can be added at the onset. The main agents involved within the progressive dwelling's completion system are two: the user-dweller, and the consulting specialists (Service of Housing and Urbanism SERVIU, and the Secretary of Communal Planning SECLAC).

In the progressive housing system, the dwelling enlargement is usually carried out over discontinued periods of time, depending on the space need and the economic possibilities of the dwellers. The design and construction activities occur almost without any previous scheduling, and usually, due to the long periods of time inbetween, the initial conditions change a lot, e.g. family dynamics, real estate market, budget, etc.

This short-term planning method, opposes to conventional housing design methods, where only after the whole house is planned, starts the construction of it.
This exceptional factor discards, in fact, every use of conventional CAD applications.
Thus, the IPSS application concept is about undertaking each design session with the goal of producing one ready-to-use inhabitable space. This is the most important challenge for the IPSS, to analyze each time the new circumstances and to search after the best adaptable design solution.

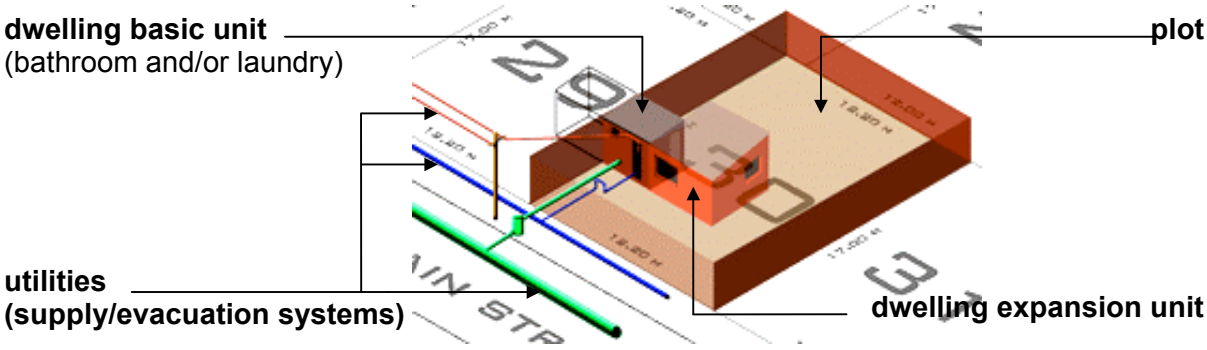

fig. 01 – physical components of a progressive dwelling

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Therefore, connection facilities for space, structure, and supply-/evacuation systems, between each enlargement unit, become a fundamental issue. In this sense, we decomposed the progressive dwelling into a collection of physical components in order to get a detailed description. (see fig. 01)

Logical structure of IPSS

In order to optimize processing energy and to facilitate the system maintenance we will structure the IPSS as a collection of modules. A module is defined as a group of activities and tasks that are carried out to produce a specific group of final products. However, the design of the GUI should present these functionally separated modules as a unified whole. The modules support: (1) acquisition and management of alphanumeric and spatial planning-relevant data, (2) preliminary design and cost estimation activities, and (3) collaborative work between specialists and consulting procedures for user-dwellers. (see fig.02)

Data acquisition module

The module will integrate a DBMS (Data Base Management System) for the indexing and retrieval of all planning-relevant data. Through the *data acquisition module* IPSS gathers all descriptive data corresponding to a specific PH development project, in order to create and to maintain file records of each planning case that be carried out with the support of IPSS. The module should be capable of retrieving data every time the user requires it during a planning or consulting session. After each session, the module is also responsible for updating the database.
The user-dweller has to deal with varied problems that are not only related to the dwelling's design, but also to its modification or reparation. Any information that be required in order to solve these problems - like for example, the graphic description of the water supply system's distribution in the house, or a reparation cost estimation - the *data acquisition module* retrieves this information from the database to be displayed on a friendly GUI.

fig. 02 - MODULES FUNCTIONALITIES

F	DATA ACQUISITION MODULE	PLANNING MODULE		CONSULTING MODULE	
MAIN FUNCTIONALITIES	creation, management and maintenance of the database	online design & evaluation of dwelling solutions		online communication between remote-located users	
EX TE	allows to access the database	IT DESIGNS	IT EVALUATES	SYNCHRONOUS	ASYNCHRONOUS

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		pre-adapting the shape and its positioning to the urban design norms	construction costs	text messaging	data transfer to external cad-systems and GIS
	shares and integrates data between different applications	pre-adapting the shape to material dimensions	growth alternatives	voice conversation	
	controls the shared access to data	pre-adapting shape to the space function	parti layout	video conversation	
			spacing need	white-board	
	assures the data integrity			3d visualization	
USERS	administrator	dweller		dweller and specialist	specialists team

Planning module

The module functionality will be based on rule-based generation methods of shape. These functionalities support the preliminary design of spaces configuration and basic constructive solutions. The processes carried out within the planning module, can be summarized as the online comparison of user's input data with the stored data that coincide with the specific problem (or object), and the display of outcomes. Based on an object-oriented approach, every element of the dwelling can be able to display physical descriptions but also methods as attribute. This enables each element to interact with the others as intelligent objects. The *planning module* should allow both, interactive design activities, and three-dimensional visualization of outcomes and alternatives. Spatial and alphanumeric data, like cost values and technical specifications, should be displayed in an understandable manner.

During the time lapsed between the abstract submission for this conference, and the deadline for the full paper submission, we started with the exploration of computational requirements for a rule-based generation method of spatial configuration solutions. It is important to mention it, because in the present article we will show a different point of view, focused at the analysis of data requirement with another level of detail used for the taxonomy. (see point 3. of system data requirement)

Consulting module

This module aims at both, the synchronous communication for consulting procedures between the user-dweller and the specialist, and the asynchronous CSCW (Computer Supported Collaborative Work) between specialists. The *consulting module* should take advantage of multimedia web-based communication techniques, like chatting, white-board, and video communication. The module is in charge of making data interpretation easier.

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Information exchange between user-dweller and specialist is mainly supported by the fact of being able to refer to a single infographic three-dimensional model, and alphanumeric linked data. The *consulting module* attempts to provide a better communication way between user-dweller and specialists, making easier to expose the ideas and questions of each one. On the other hand, this module conceives the integration of other computer aided planning tools to enable specialist's teams to work on specific aspects and other alternatives of design solutions. Indirectly, the *consulting module* will help to speed up slow and annoying approval procedures, as well as legal formalities for the construction of the user-dweller's design.
Human interaction is necessary to assure the comprehension of the problem, and the preservation of heterogeneity and individualism (singularity) of shape of each progressive house.

System data requirement

When architects design a mass housing project to participate in a public bid, they work with a lot of information. Project's descriptive data can be reorganized into file records together with data that describe construction normative, urban development regulations, and standard costs as well. These data can efficiently be processed to define the actual boundary for planning the dwelling expansion. The definition of this boundary can be carried out by automated processing. Aims are norm-adapted and cost-efficient design solutions. System's input data come from separate sources and at separate stages in time. We ordered the system input data into three main groups:

(1) The descriptive data (drawing plans, digital models, and technical specifications) of the whole settlement's project (plot allotment and urban infrastructure), and of each property type designed (plot, utilities and sanitary unit) are provided by the architects when submitting the project for the bid.

(2) The descriptive data of design normative (urban development regulations) are specified in the *Law and General Ordinance of Urbanism and Constructions*, and the possible exceptions for the specific urban area are provided by each municipality, when implementing the IPSS. These data are required for programming a sub module of the *planning module* that compares these data with the user's design intentions in order to automatically adapt his design to the norm.

(3) The descriptive data of the user-dweller are provided by her any time she accesses the IPSS with the purpose of beginning or continuing planning a dwelling enlargement. The user-dweller data can be decomposed into two main groups. One group is oriented to support decisions of sociological order, like e.g. hierarchy of needs, estimation of spacing need in relation to the number and characteristics of the dwelling's occupants, etc. The input method can be carried out by means of multiple choice forms. The second group of data is oriented to the enlargement's design, namely the shape and the positioning of the enlargement unit. The input method can be carried out by means of 3D-sketching techniques or choosing space configurations from a repertoire.[**] We first, identified the embedded information in each physical component of the PH system. Then, we made a brief selection of what data are relevant to the planning, and proposed a preliminary possible description standard of them.

[**] The input methods for user-dweller data are forthcoming.

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At the end of the paper we show the tables that correspond to the exploration of data requirements for the system.

Conclusions

IPSS supports dweller's facility management, by means of providing her with more appropriate tools in order to make optimal use of the household own resources, in response to their own needs and preferences. Many tasks involved in architectural planning of low-income housing are possible to support through automatic processing, as long as we divide them into smaller parts that require less data and less energy to be carried out. Computer supported design systems can automatically pre-adapt design solutions to different contexts, so that the user-dweller doesn't have to care about dealing with too specialized and complex information, but at the same time the legality of the project is assured. This principle can be used in order to improve dwelling quality in several aspects, like implementing security norms against fire, anti-seismic structure standards, sanitary norms for well ventilated and sunny rooms, etc. Quite near to Habraken's *Supports* concept, progressive housing offers a wide range of dwelling alternatives, but a very important interface between user-dweller and the dwelling is missing. Information Technology might fulfill this task.

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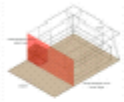
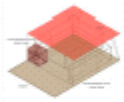
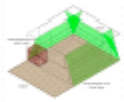
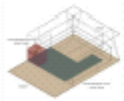
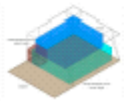
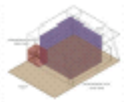
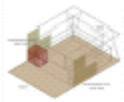
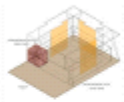
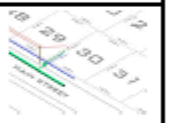
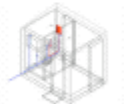
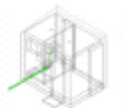
I SYSTEM DATA REQUIREMENT – INITIAL DWELLING

PHYSICAL COMPONENT	ENTITIES	DATA ATTRIBUTE	DATA DESCRIPTION	DATA CONTENT	INFOGRAPHIC MODEL
Plot	Piece of serviced land	Geographic Positioning	Endpoints 3D Coordinates	(X, Y, Z)	
		Property Lines	3D Polyline	(X, Y, Z)	
	Real estate record	Housing Program to which it belongs	Name	ID Code	
		Settlement to which it belongs			
		Block Number	ID Number	ID Code	
		Plot Number			
		Domiciliary Address assigned	Street name, Number	Alphanumeric	
	Plot type	Insertion Pattern within the settlement structure	Corner, Middle	ID Code	
	Plot walls	Geometry relative to Property Lines Coordinates	Box	Origin, Length, Height, Thickness	
	Legally-binding land-use plan	Land Uses permitted	Dwelling, Commercial premises, Workshop, Entrepreneurial.	ID Code	
		Clustering System	Continuous, Paired, Isolated	ID Code	
		Official Line	Line	(X, Y, Z)	
		Building Line	2D Surface (vertical)	Origin, Length, Width	
		Maximum Height of the building	2D Surface (horizontal)	Origin, Length, Width	
		Distance Space between buildings *wall height and openings related*	2D Surfaces (vertical)	Origin, Length, Width	
		Shadow Grade Lines	2D Surfaces (inclined)	Origin, Length, Width, Inclination Angle	
		Site Occupancy Index *Number x plot surface = max. surface to build at the first floor*	2D Surface (square horizontal Area at ground level)	Origin, Length, Width	
		Floor-Space Index *Number x plot surface = max. surface to build at each upper floor*	2D Surface (square horizontal Area at upper level)	Origin, Length, Width	
		Cubic Index *Number x plot surface = max. total surface to build on the plot*	3D Boxes Union (extrude the free-to-build Areas, then add)	Origin, Length, Width, Height	
		Adjacent Surface Index *max. neighbor-adjacent surface per side*	2D Surfaces (square vertical Area)	Origin, Length, Width	
		Openings Surface Index *max. windows surface on each neighboring wall regarding to its material and thickness*	2D Surfaces (square vertical Area)	Origin, Length, Width	
Utilities	Water supply system	Pipes Layout (isometric)	3D Polyline	(X, Y, Z)	
		Fittings	Points	(X, Y, Z)	
		Inlets			
		Outlets			
		Technical specifications	Description text	ID Code	
	Sewage system	Pipes Layout (isometric)	3D Polyline	(X, Y, Z)	
		Fittings	Points	(X, Y, Z)	
		Inlets			
		Outlets			
		Technical specifications	Description text	ID Code	
	Electricity supply system	Pipes Layout (isometric)	3D Polyline	(X, Y, Z)	
		Fittings	Points	(X, Y, Z)	
		Inlets			
		Outlets			
		Technical specifications	Description text	ID Code	
	Gas supply system *	idem	idem		

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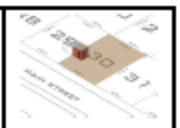
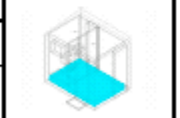
Dwelling Basic Unit	Space Function	Bathroom (shower, bathtub) Laundry / Drying Facility Extra Room	Name	ID Code	
	Interior Space	Natural Ventilation Openings *min. windows surface per space on exterior walls*	2D Surface (square vertical Area)	Origin, Length, Width	
		Air Volume *min. interior space air volume*	Box	Origin, Length, Width, Height	
	Floor	Position *Plot's coordinate system*	3D Coordinates	(X, Y, Z)	
		Geometry	Box	Length, Width, Thickness	
		Materiality	Description text	ID Code	
	Walls	Neighboring wall, interior wall, exterior wall	Name	ID Code	
		Structural or Non-Structural	Name	ID Code	
		Position *Plot's coordinate system*	3D Coordinates	(X, Y, Z)	
		Geometry	Box	Length, Height, Thickness	
		Materiality	Description text	ID Code	
	Roof	Position *Plot's coordinate system*	3D Coordinates	(X, Y, Z)	
		Geometry	Wedge	Length, Width, Height	
		Direction of Water's Gradient	Rotation Angle of wedge about the Z axis	Angle	
		Materiality	Description text	ID Code	
	Windows	Position *Wall's coordinate system*	3D Coordinates	(X, Y, Z)	
		Geometry	Box	Length, Height, Thickness	
		Materiality	Description text	ID Code	
	Doors	Position *Wall's coordinate system*	3D Coordinates	(X, Y, Z)	
		Geometry	Box	Length, Height, Thickness	
		Materiality	Description text	ID Code	
	Furniture / Devices	Bed (couple, single) Closet Lavatory Bathtub Shower WC Oven Refrigerator Dishwasher Couch Dinner Table	Name	ID Code	
		Position *Floor's coordinate system*	3D Coordinates	(X, Y, Z)	
		Geometry	Box	Length, Width, Height	

These components correspond to the initial dwelling that the user-dweller buys to the state.
* gas utilities depend on the project.

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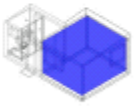
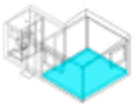
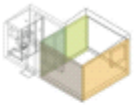
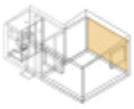
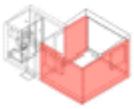
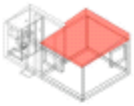
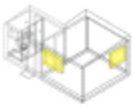
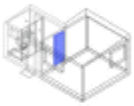
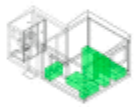
E SYSTEM DATA REQUIREMENT – DWELLING EXPANSION

PHYSICAL COMPONENT	ENTITIES	DATA DESCRIPTION	DATA DESCRIPTION	DATA CONTENT	INFOGRAPHIC MODEL
Dwelling Expansion Unit	Space Function	Bedroom (couple, n° pers.) Bathroom (shower, bathtub) Living-room Kitchen Shop Workshop (type) Terrace	Name	ID Code	
	Interior Space	Natural Ventilation Openings *min. windows surface per space* *on exterior walls*	2D Surface (square vertical Area)	Origin, Length, Width	
		Air Volume *min. interior space air volume*	Box	Origin, Length, Width, Height	
	Floor	Position *Plot's coordinate system*	3D Coordinates	(X, Y, Z)	
		Geometry	Box	Length, Width, Thickness	
		Materiality	Description text	ID Code	
	Walls	Neighboring wall, interior wall, exterior wall	Name	ID Code	
		Structural or Non-Structural	Name	ID Code	
		Position *Plot's coordinate system*	3D Coordinates	(X, Y, Z)	
		Geometry	Box	Length, Height, Thickness	
		Materiality	Description text	ID Code	
	Roof	Position *Plot's coordinate system*	3D Coordinates	(X, Y, Z)	
		Geometry	Wedge	Length, Width, Height	
		Direction of Water's Gradient	Rotation Angle of wedge about the Z axis	Angle	
		Materiality	Description text	ID Code	
	Windows	Position *Wall's coordinate system*	3D Coordinates	(X, Y, Z)	
		Geometry	Box	Length, Height, Thickness	
		Materiality	Description text	ID Code	
	Doors	Position *Wall's coordinate system*	3D Coordinates	(X, Y, Z)	
		Geometry	Box	Length, Height, Thickness	
		Materiality	Description text	ID Code	
	Furniture / Devices	Bed (couple, single) Closet Lavatory Bathtub Shower WC Oven Refrigerator Dishwasher Couch Dinner Table	Name	ID Code	
		Position *Floor's coordinate system*	3D Coordinates	(X, Y, Z)	
		Geometry	Box	Length, Width, Height	

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Utilities	Water supply system	Pipes Layout (isometric)	3D Polyline	(X, Y, Z)	
		Fittings	Points	(X, Y, Z)	
		Inlets			
		Outlets			
		Technical specifications	Description text	ID Code	
	Sewage system	Pipes Layout (isometric)	3D Polyline	(X, Y, Z)	
		Fittings	Points	(X, Y, Z)	
		Inlets			
		Outlets			
		Technical specifications	Description text	ID Code	
	Electricity supply system	Pipes Layout (isometric)	3D Polyline	(X, Y, Z)	
		Fittings	Points	(X, Y, Z)	
		Inlets			
		Outlets			
		Technical specifications	Description text	ID Code	
	Gas supply system *	idem	idem		
* eventually					

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